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Does Energy Intensity Affect the Relationship Between Financial Development and Environmental Pollution?

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Abstract: *This paper examines the role of energy intensity on the relation between financial development and environmental pollution for BRICS countries consists of the period 1990-2015. Financial development indicates the countries' currency capacities, which is significant for net energy importer countries that need currency to sustain their energy import. Additionally, for all countries, environmental degradation is important for sustainable growth. So in this study, we employ Panel Smooth Transition Regression Model (PSTR) to evaluate the "threshold" level of energy intensity which has vital role for consumption of energy. The findings indicate that for full sample there are three energy intensity threshold points. Above the threshold point (11.4%), an increment in financial development index causes more environmental pollution. However, below that energy intensity threshold point, an increase in financial development negatively affects environmental pollution. So this study may be a guide for decision makers and political authorities for sustainable energy supply and sustainable environment.*

Keywords: *CO2 emission; environmental pollution; energy intensity; financial development.*

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1. Introduction

In scholarly literature, the explicit connection between energy consumption and CO_2 emission has been researched. As findings indicate that energy consumption with using high intensity-carbon fuel is the biggest cause to an environmental degradation. For example, based on the assessment of relation between energy consumption and carbon dioxide emissions in China, unidirectional causality from energy consumption to long-term carbon emissions is observed in Granger causality test (Zhang & Cheng, 2009). The other papers which investigate the relationship in the United States, EU member countries and BRIC countries also show causality from energy consumption to environmental pollution (carbon-dioxide emissions) (Soytas & Sari, 2007; Soytas & Sari, 2009; Pao & Tsai, 2010). So, countries' energy demand for grater output causes much more CO_2 emissions than other factors.

There are substantially main constituents in countries' increasing rate of energy demands such as industrialization, growth of the economy that means increment in GDP, urbanization, high technology usage, low performance in energy efficiency and etc. Both developed countries and emerging markets need energy resources for sustainable economic growth in particular. And to enhance economic output; financial development, -including financial depth, financial openness, financial market access and financial institutions' quality- is a prominent factor. While these instruments are drivers of investment and R&D expenditures in developed countries, they are also indicators of currency capacity in net energy importer countries. Countries need to be financially developed in order for them to be able to import energy. Otherwise, they would not find sufficient energy resources and could not sustain economic growth. Carbon dioxide emission, in other words, environmental pollution is critical for countries that can import and use a great amount of energy. In this sense, the literature has researched the link between development of financial system and CO_2 emissions. According to result, an increase or a decrease in financial development index affects the environmental quality (Tamazian et al., 2019).

In this context, energy efficiency or energy intensity takes a crucial role to maintain the economic growth with low energy consumption. Because energy intensity is an indicator of an amount of energy use to produces one unit of GDP in the production process (Aydin & Esen, 2017; Ray, 2011). So, high energy-intensity means that a country uses energy resources less efficiently. High energy intensive sectors consume more energy than the low energy intensive sector for the same amount of output.

Therefore, these sectors produce more carbon-dioxide and they affect the environmental quality negatively.

2. Problem Statement

The causality between financial development and CO_2 emission or in the other words environmental pollution is one of the most debated and addressed issues within the development process of economy. In recent studies show evidence of the great importance of understanding how much country's development of financial system is included to environmental pollution. These studies searching the linkage between financial development and environmental pollution are focused on linearity of this relationship in general. So literature can be divided into two groups; 1) Empirical studies confirm the relationship between financial development and degradation of the environment, which posits a positive linearity, 2) Empirical studies confirm the relationship between financial development and degradation of the environment, which posits a negative linearity.

In the first group, the relationship between trade openness, financial development and carbon emissions is investigated using the ARDL boundary test by Bekhet et al. (2017) for the Gulf Cooperation Council countries from 1980 to 2011 and by Shahzad et al. (2017) for Pakistan from 1971 to 2011. The findings prove a unidirectional relation from trade openness and financial development to carbon emission in long-run equilibrium in Pakistan and in Oman. Siddique (2017) also studies the effect of financial advancement on environmental damage by carbon emission in Pakistan by using ARDL bound test with the period of 1980-2015. The findings support the results of Shahzad et al. (2017) study that there is a positive path way from trade openness, developed financial system depth and advanced financial market to carbon emission. Alam et al. (2015) test the relation between energy demand and financial development in SAARC member countries over a period of 1975-2011. Results prove that financial development plays a major role in increasing energy demand in countries that leads to more carbon emission. Ziaei (2015) studies role of financial advancement on CO_2 emission in the countries of Europe, East Asia and Oceania with the period of 1989-2011 and according to results, increasing carbon emission is also driven by developed financial system. Ganda (2019) and Cetin and Ecevit (2017) investigate the environmental impact of financial development in OECD countries and in Turkey respectively. The findings prove that there is a in both OECD countries and Turkey,

increasing in financial development index causes an increment in environmental pollution.

In the second group, Yuan et al. (2019) measure how financial development changes the quality of the environment in China by using data from 285 prefecture-level cities within 2003-2015 periods. According to the results, increasing in financial development causes a decreasing in environmental pollution except megacities. The other studies (Yuxiang & Chen, 2010; Ji & Zhang, 2019; Jalil & Feridun, 2011) reveal that green development in China is supported also by financial development. According to these studies, besides financial development, technology and environmental regulations are developing that reduce the carbon emission. Tamazian et al. (2019) and Saud et al. (2018) measure the adverse impact of economic and financial development on carbon dioxide emission in the BRIC countries between 1992 and 2004 and the Belt and Road Initiative countries between 1980 and 2016. The findings indicate that development in economy, financial system and trade openness leads to a less environmental pollution meaning that decreases environmental degradation.

In recent studies examining the impact of developing financial system on environment are focused on linearity of this relationship. The linearity of the financial development / environmental pollution relationship, however, is still considerable. So, the present study aims to test the linearity of the relationship under the effect of energy intensity for the BRICS (Brazil, Russia Federation, India, China and South Africa) countries by using PSTR model. These countries are emerging markets that need energy resources in order to sustain their economic development.

3. Research Questions

The present study verifies important findings that can be explained that there is a smooth non-linear link between CO_2 emissions and financial development in the economies in question. So, when energy intensity level is included, financial development does not linearly alter the level of environmental pollution in a positive or negative way. The U-shape relation is presented as geometrically. This means that when energy intensity level is higher the certain point of energy intensity, in BRICS countries, increment in financial system development expedites the carbon emission.

4. Data Set and Research Methods

This analyse examines if the effect of financial development on environmental pollution depends on the level of energy intensity based on

BRICS countries including the years from 1990 to 2015. This relationship was evaluated on the basis of model used by Yuxiang and Chen (2010); Ji and Zhang (2019); Yuan et al. (2019). The equation (1) shows the model that comprises financial development as a carbon emission factor:

$$CO_{2_{i,t}} = \alpha_0 + \alpha_1 FD_{i,t} + \varepsilon_{i,t} \quad (1)$$

Where CO_2 represents per capita CO_2 emission; FD is the financial development index; ε denotes the white noise error term; t = 1, 2, …, T time periods; and i=1, 2, 3…, N countries. We converted the model shown in Equation (1) into the PSTR model shown in Equation (2) to examine the non-linear connection between financial development and carbon emissions:

$$CO_{2_{i,t}} = \mu_i + \beta_0 FD_{i,t} + \beta_1 FD_{i,t} * g(q_{i,t}; \gamma, \theta) + \varepsilon_{i,t} \quad (2)$$

μ_i, coefficient, enables the potential of unit-specific fixed effects and qi represents the threshold variable. The term $g(q_{i,t}; \gamma, \theta)$ is employed as a transition function in Equation (2). And this term is displayed as a form of logistic function in Equation (3):

$$g(q_{i,t}; \gamma, \theta) = \left[1 + \exp(-\gamma(q_{i,t} - \theta))\right]^{-1} \quad (3)$$

In Equation (3), θ displays the threshold parameter between two regimes which are indicated as $g(q_{i,t}; \gamma, \theta) = 0$ and $g(q_{i,t}; \gamma, \theta) = 1$ terms respectively. The term γ is a smoothing parameter. This parameter specifies the smoothness of the shifting of regimes which transiting from one to another. In other words, γ represents the slope of the transition function between two threshold points.

In this study, we used the per capita CO_2 emissions as a dependant variable. We also used the financial development index (FD) as the independent variable and energy intensity as threshold variable of the model. We obtained the data of CO_2 emissions from International Energy Agency (IEA), the data of financial development index from IMF and the data of energy intensity from World Development Indicators (WDI).

5. Empirical Results

In this research, primarily cross-sectional dependence test was applied. This is because cross-sectional dependency is significant for the evaluation of estimation results to a vast scale (Breush & Pagan, 1980; Pesaran, 2004). After this test, unit root test was applied to test the stationary of the times series. Without it, the results of the analysis may be deceptive. Finally, nonlinearity of the relationship between financial development and carbon emissions was researched.

The LMadj (Adjusted Lagrange Multiplier) test presented by Breusch-Pagan[4] and deviation was adapted by Pesaran (2004) was studied for the presence of cross-sectional dependency. The findings which are observed from the analysis are stated in Table 1:

Table 1. Cross Section Dependence

	CO_2	*FD*	*Model*
CD_{BP}	27.532***	31.245***	98.525***
CD_{LM}	7.124***	8.096***	12.165***
CD	1.649**	2.257**	5.365***
LM_{adj}	4.490***	3.784***	7.598***

Significance at 10%, 5% and 1% levels are stated respectively as *, **, ***.

Table 1 represents the test statistics for per capita CO_2 emissions and Financial Development Index series. According to the test, the null hypothesis is evaluated as "the time series of countries are not dependent by cross-sectional". And there can be come out explicitly that the null has been rejected. This implies that there is cross-sectional dependence on the times series and model. So, any dramatic change in one of the countries data would have impact on the others. In addition, the LMadj (Adjusted Lagrange Multiplier) test has an important role on to select the method for the second test stage. Cross-dependence test and unit root test should be coherent to each other. Therefore, Moon and Perron's second-generation panel unit root test was applied for the stationary of the series which takes the cross-sectional dependence into consideration (Moon & Perron, 2004). Table 2 provides the finding of the analysis. According to these findings, the null hypothesis that "the series have a unit root" has been rejected for all series. So, the series are stationary at level [I(0)].

Table 2. Results of Moon and Perron's[9] panel unit root tests

Full Sample	CO_2	FD
$\hat{r}$	2	3
t_a^*	-15.038 (0.000)	-19.722 (0.000)
t_b^*	-12.846 (0.028)	-9.598 (0.038)
$\hat{\rho}_{pool}^*$	0.842	0.864

Notes: $\hat{r}$ is the estimated number of common factors. t_a^* and t_b^* are the unit root test statistics based on de-factored panel data. Corresponding p-values are in parentheses. $\hat{\rho}_{pool}^*$ is the corrected pooled estimates of the autoregressive parameter.

In the final stage, the linearity of the relation was tested by using PSTR model. For the first part of the PSTR analysis, Wald Tests (LM), Fisher Tests (LMF) and LRT Tests (LRT) were applied both for analysis of the linearity in all models and to evaluate the amount of transition functions.

Table 3. Tests for the linearity

Threshold variables (*Energy Intensity*)	*Model*
$H_0 : r = 0 \; vs \; H_1 : r = 1$	
LM	26.155*** (0.000)
LM_F	15.490*** (0.000)
LR	29.202*** (0.000)

Significance at 5% and 1% levels is stated respectively as **, ***.

According to the data of Table 3, the null hypothesis asserts that, there is no threshold value in the model. However, as indicated in the outcomes of the LM, LMF and LRT test, the null hypothesis is rejected at the 1% level of significance and the H_1 (the alternative hypothesis) should be confirmed. This second hypothesis emphasizes that there is at least one

threshold value making the relation non-linear. So, this model should be repeated by setting null hypothesis and alternative hypothesis as "there is one threshold level and there are at least two threshold levels, respectively". The aim is to determine the number of the threshold values through repeating the tests. So Table 4 indicates the results of remaining non-linearity of the PSTR model.

Table 4. Tests for the remaining non-linearity of the PSTR model

Threshold variables (*Energy Intensity*)	*Model*
$H_0 : r = 1 vs\ H_1 : r = 2$	
LM	23.820***
	(0.000)
LM_F	13.572***
	(0.000)
LR	26.312***
	(0.000)
$H_0 : r = 2\ vs\ H_1 : r = 3$	
LM	10.701***
	(0.005)
LM_F	5.382***
	(0.006)
LR	11.167***
	(0.004)
$H_0 : r = 3\ vs\ H_1 : r = 4$	
LM	0.080
	(0.961)
LM_F	0.037
	(0.964)
LR	0.080
	(0.961)

Significance at 5% and 1% levels is stated respectively as **, ***.

Table 4 shows that, the null hypothesis need to be rejected with 1% significance. So according to the findings, there are at least two threshold values and three regimes by accepting the alternative hypothesis. The next stage is to find the exact number of regimes and threshold effects.

Consequently, the H_1, alternative hypothesis, indicating that "model has two threshold values" was again evaluated against the null hypothesis which states that there are at least three threshold values. At this point, null hypothesis was rejected again and the alternative hypothesis was confirmed with 1% significance and tested for the next stage. At the final stage, the null hypothesis was settled as "there are three threshold values". Alternative hypothesis is that there are at least four threshold values. In this final test, the null hypothesis cannot be rejected. So, it can be concluded that the model has three threshold effects and four regimes. After determining the number of threshold values, the next analysis is to examine the way of nonlinear relationship between financial development and carbon emissions by using four-regime PSTR model for sample. Table 5 shows the results of estimation.

Table 5. Estimated results of the PSTR model

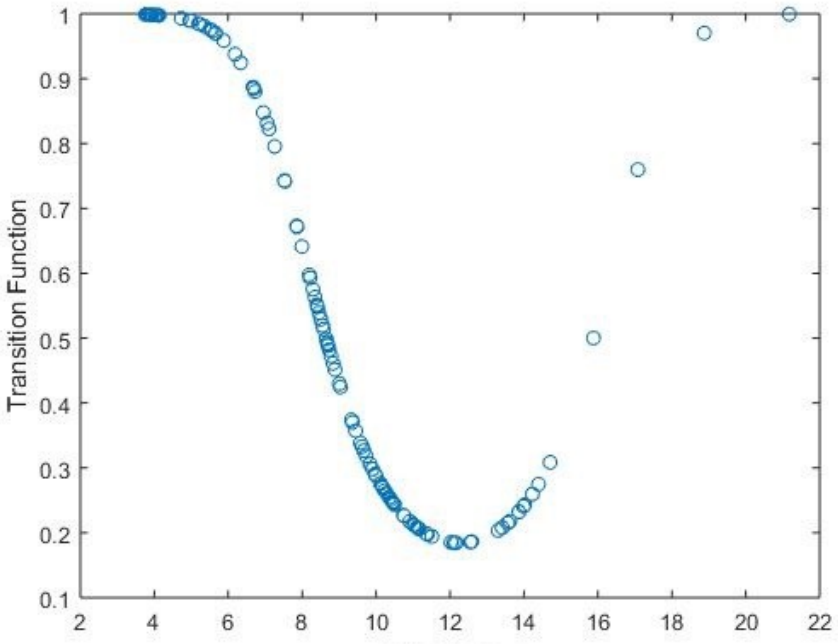
Threshold variables (Energy Intensity)	Model
FD_1	-20.625***
	(2.236)
FD_2	4.987***
	(1.225)
FD_3	8.157***
	(1.057)
FD_4	17.477***
	(1.260)
Location parameters, θ	8.642
	10.433
	11.443
Slope parameters, γ	0.000
	0.497
	0.113

Standard errors are corrected for heteroskedasticity in parentheses. *** indicates the 1% significance level.

The statistics, presented in Table 5, explain that the estimated slope parameters are ranging from 0.000 to 0.497. So, they are relatively small in all models. This implies that there is a continuum of circumstances between

regimes - that is, the relationship between per capita CO_2 emissions and the financial development index smoothly switches from one regime to another regime as showed in Figure 1:

Figure 1. Estimated transition function of the PSTR model



The model's assessment demonstrates that an increment in financial development index decreases per capita CO_2 emissions and, after reaching the first energy intensity threshold (θ=8.642), such an increase reduces per capita CO_2 emissions. The connection, however, is still negative. On the other hand, when an increase in the financial development index reaches the second energy intensity threshold (θ=10.433), the effect of increased the financial index on per capita CO_2 emission decreases less compared to the previous regime and is negative. When an increase in the financial development index reaches the third energy intensity threshold (θ=11.443), the effect of increased the financial index on per capita CO_2 emission increases and is positive.

6. Discussions and Conclusion

Financial development has gained a great importance, especially following the financial crisis in 2008 both in terms of countries' sustainable growth and their implementation of fiscal and monetary policies. On the other hand, global challenges like climate change and efficiency of greenhouse gas emissions and their causes have been studied in the literature besides in recent years; relationship between financial development and global pollution has been investigated. Main objective of these efforts emanates from countries' prioritization of not only their economic development but also the development of their financial systems. Question of this research subject is "Does carbon emission increase while countries developing financially?"

According to the researches, financial development linearly affects the carbon emission. That is to say, development in the financial systems of researched countries either increases or decreases the carbon emission. However a gap in literature is standing out at this point. Is there a non-linear relationship between financial development index and environmental pollution?

Recent study tested the linearity of the relationship between financial development and carbon emission under the effect of energy intensity using Panel Smooth Transition Regression model for BRICS countries with annual data from 1990 to 2015. The findings show that there are three threshold levels of energy intensity. These threshold levels are 8.62%, 10.43% and 11.44%. The increase in financial development for the all countries reduces the CO_2 emission dramatically until energy intensity level reaches the first energy intensity threshold level (θ=8.642). After this threshold level, the relationship still remains negative until the energy intensity threshold level reaches the point (θ=11.443). However, the effect of increment in financial development index on CO_2 emission is lighter in these regimes. When the energy intensity level over step the threshold level (θ=11.443), the rise in financial development leads to higher CO2 emissions.

The present study verifies important findings that can be explained as; firstly, there is a smooth non-linear link between CO_2 emissions and financial development in the economies in question. The findings indicate that when energy intensity level is included, financial development does not linearly alter the level of environmental pollution in a positive or negative way. Secondly; the geometrical represent of the relation is U-shape. This means that when energy intensity level is lower than 11.44%, financial development contributes to the environmental quality. But after this certain

point, in BRICS countries, increment in financial system development expedites the carbon emission. So the main object is the energy intensity level in these countries in terms of green development. To guarantee a sustainable future for the all countries, policy makers should integrate energy intensity level to economic and financial development projections.

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